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TESTS OF CHEMICAL COMPOUNDS AGAINST FABRIC INSECTS [1]

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There are here presented the results of laboratory tests to determine whether the compounds listed have any possible value as mothproofing agents. Two distinct methods of evaluation were employed. Certain preliminary steps in the procedure were common to both methods. Small squares of woolen cloth were immersed for about 10 minutes in a 0.5-percent solution in acetone of the compound to be tested and then allowed to dry. These squares were later exposed to the attack of the insects, under conditions favorable to them.

First Method.--The samples of cloth were subjected to progressively severe tests until eliminated, as follows: (I) Eggs of the webbing clothes moth (*Tineola bisselliella* Hüm.), (II) eggs of the furniture carpet beetle (*Anthrenus vorax* Waterh.), (III) larvae of the webbing clothes moth, and (IV) larvae of the furniture carpet beetle. The cloth was exposed to the attack either of the larvae that hatched from ten eggs or of ten 6-weeks-old larvae, and those samples that caused 100-percent mortality in 6 weeks were subjected to the next test. In the accompanying list the Roman numerals indicate the tests required to eliminate the compound. The higher the numeral, the more effective the compound.

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[1] All the organic compounds tested were furnished by the Division of Insecticide Investigations.

Second Method.--Partially grown larvae of the furniture carpet beetle were taken from a large culture and selected for size by eliminating the smaller and larger larvae. The selected larvae were placed in pill boxes, 10 larvae, taken at random, in each box, together with a piece of treated cloth weighing about 50 mg. The boxes were incubated at 30° C. during the test period of 6 weeks. The cloth was weighed at the beginning and again at the end of the test. After corrections had been made for changes in moisture content, the difference in weight indicated the actual damage to the cloth by each group of larvae. The final evaluation is the ratio of this damage to the damage caused by a group of 10 larvae, under like conditions, to a sample of cloth treated with a standard mothproofing agent (sodium fluosilicate). Thus, compounds less effective than the standard mothproofing agent have numbers greater than 1, and vice versa. These ratios are shown by the arabic numbers following the compounds tested by this method.

Heterocyclic compounds with sulfur in ring:

p-Aminophenylammonium-2-benzothiazolyl sulfide	$\underline{SC_6H_4N}CSNH_3C_6H_4NH_2$	I
p-Phenylene-bis(ammonium-2-benzothiazolyl sulfide)	$(\underline{SC_6H_4N}CSNH_3)_2C_6H_4$	I
Thianthrene	$\underline{C_6H_4SC_6H_4S}$	9.1

Heterocyclic compounds with sulfur outside ring:

N-Fural-S-(o-nitrophenyl)-sulfuramine	$NO_2C_6H_4SNC(C_4H_3O)$	8.3
N-(p-Acetaminophenylsulfonyl)-morpholine	$CH_3CONHC_6H_4SO_2N(CH_2CH_2)_2O$	I
N-(3-Nitro-p-tolylsulfonyl)-morpholine	$CH_3C_6H_3(NO_2)SO_2N(CH_2CH_2)_2O$	I
Piperidine piperidyl dithiocarbamate	$(C_5H_{10}N)C(S)SH(C_5H_{11}N)$	I

Heterocyclic compounds with 5-membered rings, not containing sulfur:

2,7-Dibromo-9-furalfluorene	$Br\underline{C_6H_3C[CH(C_4H_3O)]}C_6H_3Br$	I
3-Aminodibenzofuran	$\underline{C_6H_4O}C_6H_3NH_2$	II
Indole	$\underline{C_6H_4CH=CHNH}$	II
2-Methylbenzimidazole	$\underline{C_6H_4N=C(CH_3)N}H$	I
N-Xenyl-2-furamide	$(C_4H_3O)CONHC_6H_4C_6H_5$	12.3
Piperonal semicarbazone	$\underline{OCH_2O}C_6H_3CHNNHCONH_2$	11.0

Heterocyclic compounds with 6-membered rings, not containing sulfur:

Phenazine	$\underline{C_6H_4NC_6H_4N}$	I
6-Nitro-2,3-diphenyl-quinoxaline	$NO_2\underline{C_6H_3N=C(C_6H_5)C(C_6H_5)=N}$	I

Heterocyclic compounds with 6-membered rings, not containing sulfur, continued:

2-p-Nitrophenyl-3-phenylquinoxaline	$\underline{C_6H_4N{=}C(C_6H_4NO_2)C(C_6H_5){=}N}$	I
Benzo-(a)-naphtho-(2,1-c)-phenazine	$C_{24}H_{14}N_2$	I
Coumarin	$\underline{C_6H_4CHCHC(O)O}$	I
2,2,6,6-Tetramethyl-1-nitroso-4-piperidone	$(CH_3)_2\underline{CCH_2COCH_2C(CH_3)_2N}NO$	II
1,4-Diphenylpiperazine	$C_6H_5N(CH_2CH_2)_2NC_6H_5$	I
1,4-Dinitrosopiperazine	$ONN(CH_2CH_2)_2NNO$	I, II, III
Piperazine (hydrate)	$\underline{HN(CH_2)_2NH(}CH_2)_2 \cdot 6H_2O$	I
Acridan	$\underline{C_6H_4CH_2C_6H_4NH}$	I
3-Acetyl-6-methyl-1,2-pyran-2,4(3)dione (dehydroacetic acid)	$O\underline{CCHC(CH_3)OC(O)C}HCOCH_3$	I

Amines and amides containing sulfur:

p-Bromobenzenesulfonamide	$BrC_6H_4SO_2NH_2$	II, III, IV
m-Nitrobenzenesulfonamide	$NO_2C_6H_4SO_2NH_2$	II
m-Nitro-N-phenylbenzenesulfonamide	$NO_2C_6H_4SO_2NHC_6H_5$	II
N-Methyl-p-toluenesulfonamide	$CH_3C_6H_4SO_2NHCH_3$	II
N,N-Dimethyl-p-toluenesulfonamide	$CH_3C_6H_4SO_2N(CH_3)_2$	II, III
N-Methyl-N-p-tolyl-p-toluenesulfonamide	$CH_3C_6H_4SO_2N(CH_3)C_6H_4CH_3$	I

Amines and amides containing sulfur, continued:

N-p-Tolyl-p-toluenesulfonamide	$CH_3C_6H_4SO_2NHC_6H_4CH_3$	I
p-Toluenesulfonamide	$CH_3C_6H_4SO_2NH_2$	II
N-Sodium-N-chloro-p-toluenesulfonamide	$CH_3C_6H_4SO_2NClNa$	II
N-Ethyl-p-toluenesulfonamide	$CH_3C_6H_4SO_2NHC_2H_5$	II
N-n-Butyl-p-toluenesulfonamide	$CH_3C_6H_4SO_2NHC_4H_9$	II
N,N-Dichloro-p-toluenesulfonamide	$CH_3C_6H_4SO_2NCl_2$	II
p-Toluenesulfonanilide	$CH_3C_6H_4SO_2NHC_6H_5$	II
N-Methyl-p-toluenesulfonanilide	$CH_3C_6H_4SO_2N(CH_3)C_6H_5$	II
p-Bromobenzenesulfonanilide	$BrC_6H_4SO_2NHC_6H_5$	II
m-Nitro-N-1-naphthylbenzenesulfonamide	$NO_2C_6H_4SO_2NHC_{10}H_7$	II
3-Nitro-p-toluenesulfonamide	$CH_3C_6H_3(NO_2)SO_2NH_2$	I, II, III
3-Nitro-N-phenyl-p-toluenesulfonamide	$CH_3C_6H_3(NO_2)SO_2NHC_6H_5$	I
3-Nitro-N-1-naphthyl-p-toluenesulfonamide	$CH_3C_6H_3(NO_2)SO_2NHC_{10}H_7$	I
p-Bromo-N-1-naphthylbenzenesulfonamide	$BrC_6H_4SO_2NHC_{10}H_7$	I, II, III
p-Bromo-N,N-dibenzylbenzenesulfonamide	$BrC_6H_4SO_2N(CH_2C_6H_5)_2$	I, III

Amines and amides containing sulfur, continued:

S-(o-Nitrophenyl)-sulfuramine	$NO_2C_6H_4SNH_2$	12.6
N-Benzylidene-S-(o-nitrophenyl)-sulfuramine	$NO_2C_6H_4SN{=}CHC_6H_5$	13.6

Sulfides, sulfones, and mercaptans:

n-Butyl sulfone	$(C_4H_9)_2SO_2$	I
p-Tolyl sulfone	$(CH_3C_6H_4)_2SO_2$	I
Phenyl sulfone	$(C_6H_5)_2SO_2$	I
p-Phenylsulfonylphenetole	$C_6H_5SO_2C_6H_4OC_2H_5$	II
Bis(3-nitrophenyl)sulfone	$(NO_2C_6H_4)_2SO_2$	II
1-(o-Nitrophenylmercapto)-2-naphthol	$NO_2C_6H_4SC_{10}H_6OH$	15.5
Acetonyl-o-nitrophenyl sulfide	$NO_2C_6H_4SCH_2COCH_3$	7.6
4-(o-Nitrophenylmercapto)-resorcinol	$NO_2C_6H_4SC_6H_3(OH)_2$	12.2

Aldehydes, ketones, thioaldehydes, and thioketones:

2-Nitrofluorenone	$\underbrace{C_6H_4COC}_{}{}_6H_3NO_2$	I
2-[alpha-(2-Hydroxy-6-oxo-4,4-dimethyl-Δ-cyclohexenyl)ethyl]-5,5-dimethyl-1,3-cyclohexanedione	$\underbrace{COCH_2C(CH_3)_2CH_2COC}_{}HCH(CH_3)\underbrace{CCOCH_2C(CH_3)_2CH_2CO}_{}$	I

Aldehydes, ketones, thioaldehydes, and thioketones, continued:

alpha-(p-Chlorobenzoyl)-beta-phenyl ethylene oxide	$ClC_6H_4CO\underbrace{CHOC}HC_6H_5$	I
alpha-Phenyl-beta-(p-toluyl) ethylene oxide	$C_6H_5\underbrace{CHOC}HCOC_6H_4CH_3$	I
alpha-Benzoyl-beta-phenyl ethylene oxide	$C_6H_5CO\underbrace{CHOC}HC_6H_5$	I
alpha-Benzoyl-beta-(m-nitrophenyl)ethylene oxide	$C_6H_5CO\underbrace{CHOC}HC_6H_4NO_2$	I
3,4-Dichloroacetophenone	$Cl_2C_6H_3COCH_3$	9.6
p,omega-Dichloroacetophenone	$ClC_6H_4COCH_2Cl$	II
1-Phenyl-1,2-butanedione-2-monoxime	$C_6H_5COC(NOH)CH_2CH_3$	II
2,3-Pentanedione-3-monoxime	$CH_3CH_2C(NOH)COCH_3$	II
2,3-Octanedione-3-oxime	$CH_3(CH_2)_4C(NOH)COCH_3$	II
2,3-Butanedione-3-monoxime	$CH_3COC(NOH)CH_3$	II
Benzylidenediacetophenone	$C_6H_5CH(CH_2COC_6H_5)_2$	9.1
2-Hydroxybenzylidenediacetophenone	$HOC_6H_4CH(CH_2COC_6H_5)_2$	8.1
Dibenzylidenetriacetophenone (isomer B)	$[C_6H_5COCH_2CH(C_6H_5)]_2CHCOC_6H_5$	13.0
Benzil monosemicarbazone	$C_6H_5COC(C_6H_5)NNHCONH_2$	3.6

Phenols and phenol ethers:

Catechol	$C_6H_4(OH)_2$	II
2,7-Dihydroxynaphthalene	$HOC_{10}H_6OH$	II
4,6-Dibromo-o-cresol	$Br_2C_6H_2(CH_3)OH$	I

Phenols and phenol ethers, continued:

Quinhydrone	$C_6H_4O_2C_6H_4(OH)_2$	I
2,4-Dinitroanisole	$CH_3OC_6H_3(NO_2)_2$	0.6

Amines, amides, imines, and imides, not containing sulfur:

p-Chloroacetanilide	$CH_3CONHC_6H_4Cl$	I
p-Bromoacetanilide	$CH_3CONHC_6H_4Br$	I
Nitroguanidine	$NH_2C(NH)NHNO_2$	II
2-Fluorylamine	$\underline{C_6H_4CH_2C}_6H_3NH_2$	II
N-Benzylideneaniline	$C_6H_5CH=NC_6H_5$	II
N-Methyl-o-acetotoluide	$CH_3CON(CH_3)C_6H_4CH_3$	I
N-Methyl-m-acetotoluide	$CH_3CON(CH_3)C_6H_4CH_3$	I
N-Methyl-p-acetotoluide	$CH_3CON(CH_3)C_6H_4CH_3$	I
o-Chloroacetanilide	$CH_3CONHC_6H_4Cl$	I
m-Chloroacetanilide	$CH_3CONHC_6H_4Cl$	I, III
o-Bromoacetanilide	$CH_3CONHC_6H_4Br$	I
m-Bromoacetanilide	$CH_3CONHC_6H_4Br$	I
p-Iodoacetanilide	$CH_3CONHC_6H_4I$	I
m-Iodoacetanilide	$CH_3CONHC_6H_4I$	I
p-Iodoacetanilide	$CH_3CONHC_6H_4I$	I
o-Iodoaniline	$IC_6H_4NH_2$	I
Tris(p-N,N-dimethylaminophenyl)methane	$[(CH_3)_2NC_6H_4]_3CH$	I
Bis(p-N,N-dimethylaminophenyl)phenylmethane	$C_6H_5CH[C_6H_4N(CH_3)_2]_2$	I

Amines, amides, imines, and imides, not containing sulfur, continued:

Bis(p-N,N-dimethylaminophenyl)methane	$[(CH)_3NC_6H_4]_2CH_2$	I
4,4-Diphenylsemicarbazide	$(C_6H_5)_2NCONHNH_2$	I, III
Ethyl ester of diphenylcarbamic acid	$(C_6H_5)_2NCOOC_2H_5$	I, III
alpha, gamma-Di-o-tolylguanidine	$(CH_3C_6H_4NH)_2C{=}NH$	I
Carbanilide	$(C_6H_5NH)_2CO$	I
Phthalonitrile	$C_6H_4(CN)_2$	25.2
2,4,2',4'-Tetrachlorodiphenylamine	$Cl_2C_6H_3NHC_6H_3Cl_2$	I
2,4,2',4'-Tetrabromodiphenylamine	$Br_2C_6H_3NHC_6H_3Br_2$	I
Benzophenone semicarbazone	$(C_6H_5)_2CNNHCONH_2$	1.5
Acetophenone semicarbazone	$C_6H_5C(NNHCONH_2)CH_3$	4.1
2-Furaldehyde semicarbazone	$(C_4H_3O)CHNNHCONH_2$	6.5
2-Octanone semicarbazone	$CH_3(CH_2)_5C(CH_3)NNHCONH_2$	19.1
Salicylaldehyde semicarbazone	$HOC_6H_4CHNNHCONH_2$	21.5
Benzaldehyde semicarbazone	$C_6H_5CHNNHCONH_2$	4.6
N-Xenylformamide	$HCONHC_6H_4C_6H_5$	15.4
N-Xenylacetamide	$CH_3CONHC_6H_4C_6H_5$	8.5
N-Xenylpropionamide	$C_2H_5CONHC_6H_4C_6H_5$	10.8
N-Xenylbenzamide	$C_6H_5CONHC_6H_4C_6H_5$	19.0
Carvacrylpropionamide	$C_2H_5CONHC_6H_3(CH_3)(C_3H_7)$	12.9
4-Methyl-2-pentanone semicarbazone	$(CH_3)_2CHCH_2C(CH_3)NNHCONH_2$	21.5

Amines, amides, imines, and imides, not containing sulfur, continued:

Crotonaldehyde semicarbazone	$CH_3CHCHCHNNHCONH_2$	8.0
2,6-Dimethyl-4-heptanone semicarbazone	$[(CH_3)_2CHCH_2]_2CNNHCONH_2$	7.3
2-Pentanone semicarbazone	$CH_3C(NNHCONH_2)C_3H_7$	5.0
p-Methylacetophenone semicarbazone	$CH_3C_6H_4C(CH_3)NNHCONH_2$	12.7
2-Butanone semicarbazone	$C_2H_5C(NNHCONH_2)CH_3$	10.6
Cyclopentanone semicarbazone	$C_5H_8(NNHCONH_2)$	12.3
Acetonylacetone disemicarbazone	$[CH_3C(NNHCONH_2)_2CH_2]_2$	18.2
alpha-Ethylbutyraldehyde semicarbazone	$(C_2H_5)_2CHCHNNHCONH_2$	14.0
alpha-Cyanoacetanilide	$CNCH_2CONHC_6H_5$	14.0
p-Chloroacetophenone semicarbazone	$ClC_6H_4C(CH_3)NNHCONH_2$	1.4
Acetoacetic acid ethyl ester semicarbazone	$CH_3C(NNHCONH_2)CH_2COOC_2H_5$	10.7
Vanillin oxime	$CH_3OC_6H_3(OH)CHNOH$	12.2
Vanillin semicarbazone	$CH_3OC_6H_3(OH)CHNNHCONH_2$	13.0
o-Chlorobenzaldehyde semicarbazone	$ClC_6H_4CHNNHCONH_2$	10.4
Levulinic acid semicarbazone	$CH_3C(NNHCONH_2)CH_2CH_2COOH$	12.6
3,4-Dichloroacetophenone semicarbazone	$Cl_2C_6H_3C(CH_3)NNHCONH_2$	4.2
2,4-Dimethyl-3-pentanone semicarbazone	$[(CH_3)_2CH]_2CNNHCONH_2$	7.4
2-Heptanone semicarbazone	$CH_3(CH_2)_4C(CH_3)NNHCONH_2$	7.0

Amines, amides, imines, and imides, not containing sulfur, continued:

p-Aminobenzophenone semicarbazone	$NH_2C_6H_4C(C_6H_5)NNHCONH_2$	1.4
Cyclohexanone semicarbazone	$C_6H_{10}NNHCONH_2$	2.7

Acids, alcohols, and esters:

Diphenyl ester of carbonic acid	$(C_6H_5O)_2CO$	I
2,4,6-Tribromophenyl ester of p-toluenesulfonic acid	$Br_3C_6H_2OSO_2C_6H_4CH_3$	I
p-Chlorophenyl ester of p'-toluenesulfonic acid	$ClC_6H_4OSO_2C_6H_4CH_3$	I
2,4-Dichlorophenyl ester of 3',4'-dichlorobenzenesulfonic acid	$Cl_2C_6H_3OSO_2C_6H_3Cl_2$	I
Phenyl ester of 3,4-dichlorobenzenesulfonic acid	$C_6H_5OSO_2C_6H_3Cl_2$	I
Phenyl ester of p-chlorobenzenesulfonic acid	$C_6H_5OSO_2C_6H_4Cl$	I
Phenyl ester of p-toluenesulfonic acid	$C_6H_5OSO_2C_6H_4CH_3$	1
o-Chlorophenyl ester of p'-toluenesulfonic acid	$ClC_6H_4OSO_2C_6H_4Cl$	I
2,4-Dichlorophenyl ester of p'-toluenesulfonic acid	$Cl_2C_6H_3OSO_2C_6H_4CH_3$	I
o-Tolyl ester of p'-toluenesulfonic acid	$CH_3C_6H_4OSO_2C_6H_4CH_3$	I
4-Chloro-m-tolyl ester of p'-toluenesulfonic acid	$ClC_6H_3(CH_3)OSO_2C_6H_4CH_3$	I
2-Bromo-9-fluorenol	$\underline{C_6H_4CH(OH)C}{}_6H_3Br$	I
Ethyl ester of alpha, beta-dibromohydrocinnamic acid	$C_6H_5CHBrCHBrCOOC_2H_5$	I

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Acids, alcohols, and esters, continued:

alpha, beta-Dibromo-hydrocinnamic acid	$C_6H_5CHBrCHBrCOOH$	I
Ethyl ester of 4-acetyl-3-hydroxy-2-naphthoic acid	$CH_3COC_{10}H_5(OH)CO_2C_2H_5$	II
p-Nitroiodosobenzene acetate	$(NO_2)C_6H_4I{=}(OCOCH_3)_2$	24.8
2,4-Dinitrophenyl ester of acetic acid	$CH_3CO_2C_6H_3(NO_2)_2$	0.7
Benzoyl peroxide	$(C_6H_5CO)_2O_2$	9.9

Nitro and nitroso compounds:

Cupferron	$C_6H_5N(NO)ONH_4$	I, II, III
N-Nitrosodibenzylamine	$C_6H_5CH_2N(NO)CH_2C_6H_5$	I, III
alpha, beta-Dibromo-beta-nitroethylbenzene	$C_6H_5CHBrCHBrNO_2$	I
o-Iodosonitrobenzene	$C_6H_4(NO_2)IO$	I, II, III
p-Iodosonitrobenzene	$C_6H_4(NO_2)IO$	I, II, III
o-Nitrophenyliodochloride	$(NO_2)C_6H_4ICl_2$	I, II, III
m-Nitrophenyliodochloride	$(NO_2)C_6H_4ICl_2$	I, II, III
p-Nitrophenyliodochloride	$(NO_2)C_6H_4ICl_2$	I, II, III

Aryl, alkyl, and aralkyl halides:

Iodosobenzene	C_6H_5IO	I, II
Pentaerythrityl bromide	$C(CH_2Br)_4$	II
alpha, beta-Dibromoethylbenzene(styrene dibromide)	$C_6H_5CHBrCH_2Br$	22.3
2-Bromofluorene	$\underline{C_6H_4CH_2C_6}H_3Br$	I, II, III

Hydrocarbon:

9,10-Dihydroanthracene	$C_6H_4(CH_2)_2C_6H_4$	I